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SEIZURE SEMIOLOGY AND SURVIVAL IN CATS WITH EPILEPSY OF UNKNOWN CAUSE: A RETROSPECTIVE STUDY OF 76 CASES

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Zusammenfassung Deutsch

Anfallssemiologie und Überlebenszeit bei Katzen mit Epilepsie unbekannter Ursache:
Eine retrospektive Studie über 76 Fälle

In dieser retrospektiven Studie wurde die Anfallssemiologie bei Katzen mit Epilepsie unbekannter Ursache (EUC) analysiert. Katzen mit >3 isolierten Anfällen, normalen klinisch-pathologischen und bildgebenden Untersuchungsresultaten sowie einer Bewertung durch Besitzerinterviews (>1 Jahr nach der Klinikentlassung) wurden in die Studie aufgenommen. Ein Fragebogen zur Erfassung der Anfallssemiologie wurde basierend auf experimentellen Epilepsiestudien entworfen. Bei 70 von 226 Katzen konnte anhand der Interviews der Anfallstyp klassifiziert werden. Ein Drittel der Katzen präsentierte sich mit primär generalisierten Anfällen und von jenen mit initial fokalen Anfällen entwickelten 78% sekundäre Generalisierung. Klinische Zeichen von generalisierten Anfällen waren plötzlicher Bewusstseinsverlust und generalisierte tonisch-klonische Anfälle, während Katzen mit fokalen Anfällen präiktale sowie unilaterale Anfallsphänomene zeigten. Eine vollständige Remission wurde bei 42% beobachtet. Die mediane Überlebenszeit betrug unabhängig des Therapieplans 3,2 Jahre (Bereich 1-11 Jahre) und 91% waren zum Zeitpunkt der Interviews am Leben. Die Überlebenswahrscheinlichkeit und der Therapieerfolg konnten nicht prognostiziert werden. Im Unterschied zu früheren Studien war eine Remission ohne die Verwendung von Antiepileptika bei einem Grossteil der Katzen mit EUC zu beobachten.

Schlüsselwörter: feline, EUC, primär generalisierte Anfälle, fokale Anfälle

Abstract

Purpose: To characterize and examine associations of seizure semiology on outcome and survival in a larger population of cats with epilepsy of unknown cause (EUC).

Methods: In this retrospective study from 1997-2012, cats with ≥3 isolated seizure events, clinicopathological and imaging examination, and re-assessment by interview with owner ≥1 year after discharge from the Vetsuisse Clinic Zürich were evaluated, and those with EUC were further examined. A questionnaire for seizure semiology was developed based upon experimental data. Seizures were categorized into (1) primary generalized seizure and (2) focal seizure onset without and (3) with secondary generalization. Outcome and treatment response were assessed.

Results: Among 226 cats with recurrent seizures, seizure semiology was characterized in 76 cats with EUC by owner interviews. The median age of seizure onset was 4 years (range 0.3-18 years) without any differences between seizure types. One third of cats with EUC presented with primary generalized seizures and 78% of those with initially focal seizures progressed to secondary generalized seizures. Clinical signs of generalized seizures included sudden onset of loss of consciousness and generalized tonic-clonic seizures, while cats with focal seizures had preictal and unilateral signs. Treatment with antiepileptic drugs was initiated in 62 cats. Complete remission rate and median survival time were 42% and 3.2 years (range 1-11 years) independent of being treated or not, and 91% were still alive at the time of interview ≥1 year after discharge from the clinic. Neither semiology nor seizure type predicted survival and outcome in cats with EUC.

Conclusions: While semiology further characterized clinically focal and generalized seizures in cats with EUC, it did not predict outcome and response to treatment. In contrast to previous studies, remission may occur in cats with EUC without the use of antiepileptic drug therapy.

Introduction

The original classification scheme for epilepsy in humans from the International League Against Epilepsy (ILAE) in 1989 divided the seizure etiologies into idiopathic, symptomatic, and cryptogenic epilepsies (Commission of ILAE, 1981, and 1989).

Idiopathic epilepsy was defined as chronic recurring seizures without any underlying structural brain lesions and other neurological signs and was presumed to be genetic in origin. Symptomatic epilepsy was due to identifiable cerebral lesions and was labeled cryptogenic, when a specific cause was not identified, but suspected due to persistent neurological signs.

The term Epilepsy of Unknown Cause (EUC) has recently been adopted to classify seizure disorders when no underlying cause can be identified. Based upon a recent classification system by the International Veterinary Epilepsy Task Force Consensus Report in 2015, EUC replaces former terms such as idiopathic epilepsy and primary epilepsy and embraces categories such as cryptogenic epilepsy and presumed idiopathic epilepsy (Berendt et al., 2015). Reported prevalences of feline EUC range between 22 and 54% (Rusbridge, 2005; Schriefl et al., 2008; Wahle et al., 2014). The main characteristic feature in cats with EUC is absence of pathological findings by diagnostic imaging and CSF analysis and/or a history of seizures with no abnormalities detected on neurologic examination during interictal periods. The median age at onset of seizures in EUC is generally <7 years, but the range varies considerably between 0.4 and 14.4 years and no breed or sex predilections could be identified (Schriefl et al., 2008; Pakozdy et al., 2010; Moore et al., 2013; Wahle et al., 2014).

Long seizure-free periods seemed to be frequently observed in treated cats with EUC. However, in up to 30% of cats seizure control was poor (Pakozdy et al., 2012). EUC includes a variety of yet to be determined etiologies, which may respond differently to antiepileptic drug (AED) therapy and also may have different outcomes (Wahle et al., 2014) .

There is a need to introduce new tools that improve characterization and prognosis of cats with EUC. Recent technological advances such as ictal video monitoring, interictal non-invasive or invasive electro-encephalography, magnet-encephalography, structural and functional magnet resonance imaging (MRI) or nuclear imaging can be helpful in the better characterization of seizure disorders of unknown etiology, but are hardly available for animals to date (Hasegawa D. et al., 2016). In contrast to these high-end technologies, informant-described seizure onset characterization and ictal behavior (semiology) are still required to

define seizure type and assess response to antiepileptic treatment. This information is readily and easily available from most cat owners and may represent the only source of information along with a clinical neurological examination because of limited ability to pursue diagnostic testing in clinical practice and infrequent seizure episodes restricting direct observation during a clinic visit.

The value of describing semiology has been demonstrated previously in cats with experimentally induced epilepsy. Following the induction of seizures by various systemically and intra-cerebrally applied pharmacological agents, detailed observations regarding seizure phenotype have been made in cats. With each experimental setting uniform and specific patterns were described suggesting that certain triggers produced characteristic seizure phenotypes (Gloor et al., 1974; Louis et al., 1990; Mutani et al., 1967; Rapport et al., 1975; Reimer et al., 1967; Fenney et al., 1998; Griffith et al., 1987; Gutnick et al., 1975; Marcus et al., 1968). The association of seizure type based upon semiological features and outcome as well as survival has not yet been examined in a larger population of cats categorized as EUC.

The purpose of this retrospective study was to collect information derived from owner interviews regarding outcome and semiology description together with clinicopathological and imaging data in order to provide clinicians with a simple tool to assess cats with EUC.

Materials and Methods

Medical records of cats with a primary complaint of seizures, presented between 1997 and 2012 to the Section of Neurology, Vetsuisse Faculty of the University of Zürich, Switzerland (Vetsuisse Clinic Zürich), were reviewed. Information on signalment, age at onset of seizures and number of seizures before presentation was retrieved. At the time of admission, all cats had to have experienced ≥3 seizure episodes that were clearly separated from each other by at least >1 day, i.e. cats with reactive seizures – which occur as a natural response of the normal brain to a transient (traumatic, metabolic, or toxic) disturbance in function – were excluded (Berendt et al., 2015). Furthermore, results of clinical and neurological examinations, hematology and serum chemistry tests and infectious disease screening were evaluated. If available, results of cerebrospinal fluid (CSF) analysis, computed tomography (CT) and/or MRI were used for analysis**.** Owners of cats with EUC were contacted by phone at least 1 year and maximally 15 years after their first presentation for seizures at the clinic. If an owner of a cat could not be reached despite various attempts, the cat was excluded from further study. All owners were interviewed by 1 of the authors (AS), and responses were also reviewed by 1 neurophysiologist (Ian Mothersill) and boarded veterinary neurologist (FS).

Seizure etiologies were determined based on the International Veterinary Epilepsy Task Force Consensus Report (Berendt et al., 2015). Cats with EUC were selected for this study based upon normal clinicopathological and imaging results including clinical and neurological examinations, hematology, serum chemistry, CSF, and CT or MRI of the brain. Furthermore, cats with EUC had no evidence of neurological disease apart from seizures at any time before and during the observation period.

Seizure type was classified based upon semiology into (1) primary generalized tonic-clonic seizures, (2) seizures with focal onset and (3) focal seizures with secondary generalization. Primary generalized seizures were characterized by acute onset of lateral recumbency and tonic-clonic limb movements accompanied by autonomic signs and loss of responsiveness. Focal seizures were defined as paroxysmal occurrences of abnormal movements of 1 part of the body, such as contractions of 1 limb or facial muscle group, with or without impairment consciousness or autonomic signs such as salivation, and involuntary urination and defecation, which could evolve into secondary generalized seizures (Wahle et al., 2014).

Interviews regarding semiology were performed using a detailed questionnaire specifically designed for the purpose of this study (Table 1). Specific questions regarding semiology were created based upon a review of the literature for clinical signs observed in experimental epilepsy studies reported in cats. We searched in PubMed and scholar.google for experimental epilepsy studies in cats from 1967 to 2010 in order to establish a list of seizure phenotypes, which were observed after experimental induction of seizures. Data from 9 experimental studies describing the semiology and the localization of the affected brain regions were selected (Gloor et al., 1974; Louis et al., 1990; Mutani et al., 1967; Rapport et al., 1975; Reimer et al., 1967; Fenney et al., 1998; Griffith et al., 1987; Gutnick et al., 1975; Marcus et al., 1968). The questionnaire contained open-ended questions for semiology to which the answers were explicitly collected.

Outcome questions included recording of survival from time of discharge, initial and subsequent clinical features of seizures, owner-perceived general health status of the cat at time of follow-up, frequency of seizures, and medical treatment required to control seizures. Partial remission was defined as reduction of seizure frequency by <50% with AED therapy at the time of follow-up. Complete remission was defined by a seizure-free period of ≥1 year with or without AED therapy. Epilepsy-related cause of death was defined as euthanasia motivated by circumstances directly associated with seizures. If the cat died or was euthanized for reasons unrelated to seizures, death was registered as due to other causes.

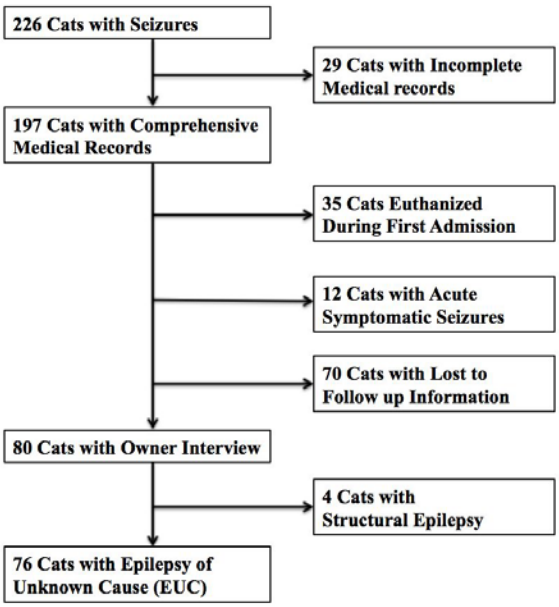
Statistics - Survival analysis using a cox proportional hazard regression model was undertaken using the coxph function in the survival package in R (Therneau, 2015). A parametric survival curve was also fitted to the data using the survreg command.
A Package for Survival Analysis in S. version 2.38, <URL: http://CRAN.R-project.org/package=survival>.

Results

Study Population

During a 15-year period between 1997 and 2012, a total of 226 cats were presented for seizures to Vetsuisse Clinic Zürich (Figure 1). Adequate medical records were available from 197 cats for further analysis. However, 35 cats died or were euthanized due to presence of intracranial pathology or by owner request during initial hospitalization, and 12 cats were found to have reactive seizures due to metabolic-toxic etiologies and were therefore excluded. Another 70 cats were excluded because owners could not be reached despite a search for contact information and multiple attempts. For 80 cats, i.e. 36% of all seizuring cats, the owners were available for follow-up information after hospitalization. Based upon additional medical record and follow-up information, 4 cats were found to have structural epilepsy (space occupying mass in frontal lobe, hydrocephalus, traumatic brain injury, post-anesthesia complications) and were therefore excluded. Thus the remaining 76 cats were considered to have EUC and were included in this retrospective study. All these cats had clinical and neurological examination, hematology and serum chemistry, and 59 cats had CSF analysis, 26 had CT, and 10 had MRI performed. No abnormalities were found by any of these diagnostic tests.

Figure 1: Selection of Seizuring Cats with Epilepsy of Unknown Cause Seen at Vetsuisse Clinic Zürich



While European shorthair cats (63 cats; 83%) were by far most commonly represented among the 76 cats with EUC, there were 9 purebred cats, including 3 Maine Coon and 2 Persian cats and 1 Siamese, Norwegian Forest, Bengal and Bombay cat; in addition there were 4 cats of unknown breed. This reflected the typical feline patient population at Veterinary Clinic Zürich (data not shown). Gender distribution was equal with 3 intact and 35 castrated males and 6 intact and 32 spayed females. The median age at seizure onset was 4 years (range of 0.3-18 years).

Semiology of Seizuring Cats

Of 76 cat owners, 6 (8%) could not recall the initial semiology, but information about general health, medications, remission rate, and survival time could be collected. The semiology of cats with EUC varied, but could be divided into focal and generalized signs of seizures based on the questionnaire (Table 1).

Table 1: Semiology Results of Owner Interview for 70 Cats with EUC: Classification of Seizure Type

Clinical Signs for Semiology	Cats	Seizure Type		
		Primary Generalization	Focal Without Secondary Generalization	Focal and Secondary Generalization
Generalized Signs				
- Tonic - clonic generalized seizures in recumbency	53	23	0	30
- Loss of consciousness	53	21	0	32
- Urination	25	10	0	15
- Defecation	3	1	0	2
Focal or Part of Generalized Signs				
- Salivation	40	15	3	22
- Rapid running (psychomotor seizures)	26	0	5	21
- Isolated twitching of facial muscle	15	0	3	12
- Circling to 1 side	12	0	2	10
- Fearful or aggressive behavior [1]	10	0	2	8
- Tonic movement in 1 limb	11	0	3	8
- Pupillary dilatation	10	1	1	8
- Pre-ictal unresponsiveness [2]	9	0	1	8
- Behavioral arrest (freezing) [3]	9	0	1	8
- Isolated twitching of the tail	5	0	3	2
Total	**70**	**23**	**10**	**37**

[1] Bite, strike, hissing, piloerection, and/or ear retraction
[2] Arrest of movement, unresponsiveness to external stimuli, and/or change in behavior (minutes to hours before seizure)
[3] Unresponsive blank staring and panting, followed by a return to normal

Cats with primary or secondary generalized seizures most often had tonic-clonic generalized seizures in lateral recumbency as well as loss of consciousness. The most

common signs seen in cats with focal onset and secondary generalized seizures were salivation and aimless running. The most common sign associated with focal seizures without progression to generalized seizures was rapid running. Other focal signs included isolated twitching of facial muscles or tail and tonic movement of 1 limb.

Seizure Type Classification Based on Semiology

Of the 70 cats with EUC and available semiology information, 23 cats (33%) had primary generalized seizures (Table 2 and 3). Clinical signs included sudden onset of loss of consciousness, primary generalized tonic-clonic seizures, salivation, urination, and/or defecation. Owners were not aware of pre-ictal signs such as changes in behavior. Owners of 4 animals reported that seizures occurred first during sleep.

Focal seizures were observed in 47 cats (67%). Pre-ictal abnormal behavior signs were noted in 9 cats minutes to hours before ictal signs occurred. The cats appeared to be awake but confused and not properly reacting to external stimuli and to the owner. Clinical signs of focal seizure activity included rapid aimless running, clonic movements of 1 body part such as tail or 1 limb, twitching of unilateral facial muscles, and circling in 1 direction. Progression from focal (motor, autonomic and/or behavioral signs) to secondary generalized seizures was observed in 78% (37/ 47) of cats with focal seizure onset.

Table 2: Semiology and Longterm Survival of 76 Cats with EUC

Seizure Type	Cats #	Median Time of Follow up[1] in Years (Range)	Status at End of Study				Mean Survival Time in Years[2]
			Dead		Alive		
			# (%)	Median in Years (Range)	# (%)	Median in Years (Range)	
Primary Generalized	23	3.3 (0.02-10)	5 (22)	0.7 (0.02-8)	18 (78)	3.5 (1.1-10)	4.9
Focal	10	3.0 (1-11)	2 (20)	4 (3-5)	8 (80)	2.5 (1-11)	
Focal with Secondary Generalized	37	1.8 (0.08-12)	16 (43)	1 (0.08-12)	21 (57)	1.5 (1-8.4)	
No Semiology Information	6	5.1 (1.3-11)	1 (17)	1.5	5 (83)	6 (1.3-11)	

[1] Time from clinic admission to follow-up interview, at least 1 year after discharge from Vetsuisse Clinic Zürich
[2] Kaplan-Meyer analysis

There was no statistical difference in the median age between cats with focal seizures and cats with primary (and secondary) generalized seizures at onset of seizures.

Outcome and Survival

Overall, the median time of follow-up of surviving cats with EUC (52; 68%) was 3.2 years (range 1-11 years). There were 24 (32%) cats, which died during the study period; and the median survival was 1 year (range 0.1-12 years). Death appeared epilepsy-related in 16 (21%) cats, and 8 patients (11%) died for other causes. Age at the time of seizure onset and remission were significant independent predictors of survival. The hazard ratio for age at onset was 1.12 (p=0.015). This means that there was a 12% increase in the risk of death per time period for each increase of 1 year of the age from onset. With the 76 cats, the mean survival time was 4.9 years. The hazard ratio of remission was 10.4 (p=0.002. Thus, the risk of death was 10 times higher in cats without remission compared to those that showed remission per time period.

Treatment with AED was used in 62 (82%) of cats during and after hospitalization. Phenobarbital was given to all treated cats either alone or in combination with diazepam (6) or levetiracetam (12). Their median survival time was 2.3 years (range 0.1-11 years), and 65% were still alive at the time of follow-up.

Figure 2. Kaplan-Meier Curve of Survival (—) and 95% CIs (•-•-•) of 76 Cats with EUC.
(-.-.-.-) = Smoothed Parametric Survival Curve

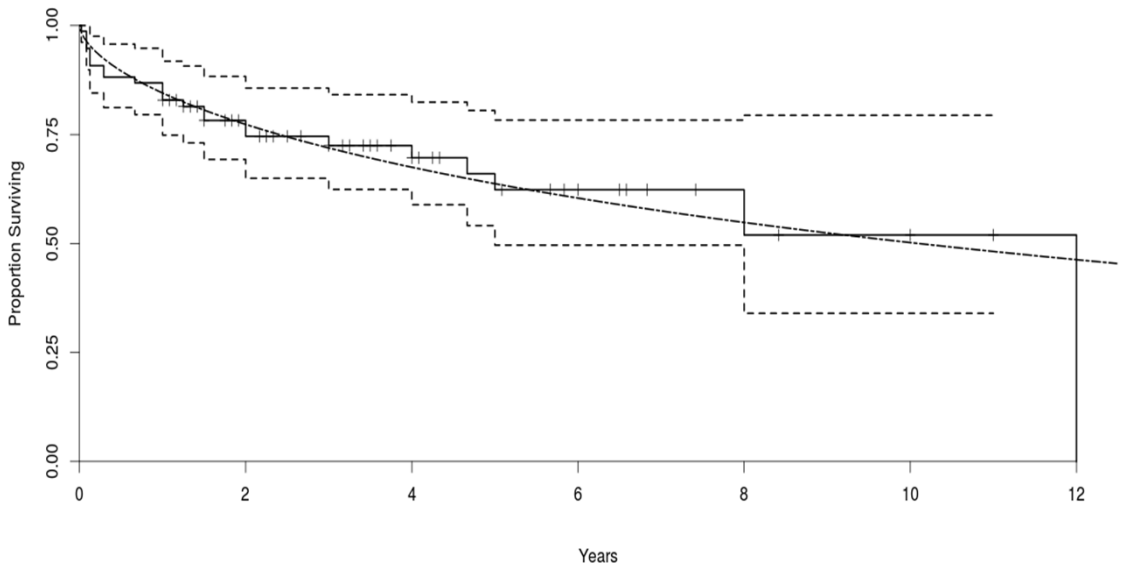
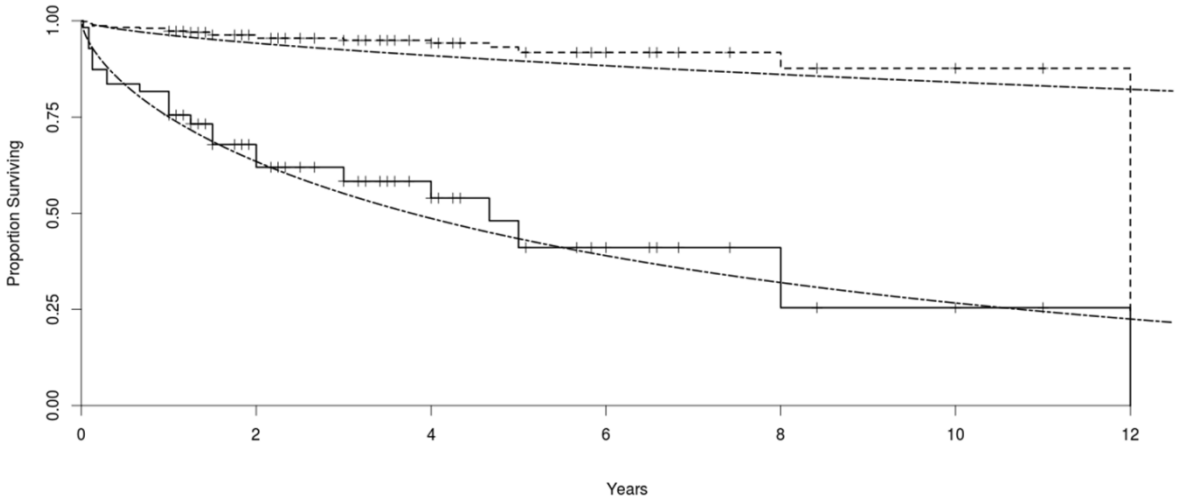


Figure 3. Kaplan-Meier Curves of Survival for 32 Cats in Remission (•-•-•) and 21 Cats not in Remission (—) of 76 Cats with EUC.

(.-.-.-) = Smoothed Parametric Survival Curves



Treatment appeared effective in 44 (71%) cats (total number of improved seizure status including cats with complete and partial remission). Complete remission with AED was achieved in 21 (34%) cats with a median time of follow-up of 4.3 years (range 1-11 years). These cats were still alive at the time of follow-up except for 1 cat, which died after 5 years due to an epilepsy unrelated cause. Partial remission was observed in 23 (37%) cats with AED therapy, and 15 were still alive at the time of follow-up (median time of 2.5 years; range 1-11 years); 8 cats died after a median survival time of 1.5 years (range 1-8 years). Death appeared epilepsy-related in 4 cats, and another 4 died for other causes. The remaining 18 (29%) cats showed no remission with AED therapy, and 13 had died at the time of follow-up with a median survival time of only 0.3 years (range 0.2-4 years). In 12/13 cats death or euthanasia was epilepsy related.

In 14 cats without AED therapy, the median time of follow-up was 2.6 years (range 1-12 years). Complete remission without AED therapy occurred in 11/14 (79%) cats with a median time of follow-up of 3.2 years (range 1-12 years). At follow-up, 12/14 (86%) cats with EUC were alive, while 2 cats deceased for other causes.

A total of 32/76 (42%) cats became seizure-free with or without AED including 14 animals with primary generalized tonic-clonic seizures, 5 with isolated focal seizures and 10 with focal seizures and secondary generalization (table 3). In 3/32 (9%) cats with complete remission death was not epilepsy-related (median survival time 5 years, range 5-12 years).

The 29 (91%) cats alive had a mean survival time of 3.2 years (range1-11 years). There was a significant difference in cats achieving remission in the presence or absence of AED treatment ($p < 0.003$). Treated cats survived significantly shorter than untreated cats.

No significant differences between semiology, seizure type, and outcome were observed, and thus neither semiology nor seizure type predicted outcome in cats with EUC ($p > 0.05$).

Table 3: Semiology and Remission Rates in 76 Cats with EUC

Seizure Type	# of Cats	Age of Onset Median in Years	Complete Remission[1]		Partial Remission[3] <50% Seizure Frequency with AED	No Remission[4]
			Total	With AED[2]		
Primary Generalized	23	3	14 (61%)	4	5	4 (17%)
Focal	10	5	5 (50%)	1	4	1(10%)
Focal with Secondary Generalized	37	4	10 (27%)	3	12	15 (41%)
No Semiology Information	6	6	3 (50%)	1	2	1 (17%)

[1] no seizures in the last 1 year with or without AED
[2] no seizures in the last 1 year under AED
[3] <50% Seizure Frequency with AED
[4] no remission with or without AED

Discussion

In this study, 68% of cats with EUC survived for a mean follow-up time period of 3.2 years (range: 1-11 years), and seizures were successfully controlled with AED's in 71% of the cats. Similarly, previous studies reported high survival rates and good outcomes in cats with EUC (Schriefl et al., 2008; Pakodzy et al., 2010; Pakozdy et al., 2012; Finnerty et al., 2014; Wahle et al., 2014). However, in many cats seizures were poorly controlled, and 21% were euthanized or died as a consequence of their seizures in the present retrospective study. Thus, identification of prognostic predictors are important for the motivation of clients to pursue treatment of cats diagnosed with EUC. The objective of this retrospective study was therefore to look for easily accessible information from clinical examination and owner interviews that allow more valid statements on outcome in affected cats.

Neither semiology nor seizure type were associated with outcome in terms of survival in the present survey. Moreover, seizure type based upon semiological classification was not predictive of seizure etiology similar to what has been previously reported (Barnes et al., 2004; Schriefl et al., 2008; Pakozdy et al., 2010). Despite this, careful recording of semiology and seizure type remains important when evaluating seizuring cats. Specific seizure disorders in cats have been reported including complex partial seizures with orofacial involvement in cats with limbic encephalitis and myoclonic seizures prior to generalized tonic-clonic seizures in cats with audiogenic reflex seizures (Pakodzy et al., 2011; Lowrie et al., 2015). Recording of the initial signs of seizure events are required for determination of the so-called 'symptomatogenic zone' defined as the area of cortex which, when activated by an epileptiform discharge, produces the ictal signs. These indicate laterality and their sequential disturbance during the ictus relate to the propagation of seizure activity. This information may be useful in conjunction with electroencephalogram EEG and functional MRI, i.e. when surgical removal of seizure foci in epileptic cats will become a practical treatment option (Hasegawa et al., 2016).

In the present study, we found that age at time of seizure onset was significantly associated with survival. Specifically, the risk of death in a cat with EUC increases 12% for each year after time of onset of seizures. This information should be of interest when discussing prognosis with cat owners. Furthermore, there was a significant association of survival with remission, i.e. cats with remission survived longer than those without. Many cats (21%) died for causes directly associated with seizures and as a consequence, remission

is likely to go along with prolonged survival. As this result cannot be used for prognosis at the time of diagnosis, it is of limited value and more of general consideration.

The overall rate of complete remission of 42% in this study was in accordance with the results of previous surveys. Thus, feline EUC is manageable and may have a favorable outcome (Wahle et al., 2014). Our finding that the rate of complete remission was significantly higher in cats without AED compared to those with AED (79% vs. 34%) was unexpected, albeit there have been no large surveys evaluating outcome and response to treatment in cats with EUC. In a previous small case study, phenobarbital treatment was regarded to be required to maintain a seizure free status because seizures recurred in 6/8 (86%) of cats in which medication was discontinued or reduced (Pakozdy et al., 2012). However, our findings are in accordance with another recent small case study in which seizure remission was achieved in 3/5 (60%) cats without treatment (Wahle et al., 2014). It is well possible that there are different subtypes of EUC not requiring neither any nor continuous AED treatment. Thus, the inability to administer AED twice daily does not preclude that a seizure-free status can be obtained.

Despite the wide availability of digital devices that record seizure events, detailed interviews with owners remain an important source of information for clinical signs of true seizure onset (De Risio et al., 2015). In the present study, interviews were required to categorize the seizure type into primary generalized seizures and focal onset seizures with or without secondary generalization. While helpful, many “homemade” video tapes fail to document the entire epileptic event, which may lead to erroneous classification of the seizure type (Packer et al., 2015). Compared to videos, owner-derived observations about seizure, however, appear less reliable, because of recall bias, and, therefore, 1 might question their use for diagnostic purposes. In human epileptology the dilemma is identical because epileptic patients may not describe their symptoms and information about semiology has to be provided by individuals who have witnessed the seizures. In 1 semiology investigation of human patients with EUC, seizure types based on observer description were correctly classified in 85% of patients when compared with the findings from the video tapes (Heo et al., 2008). The accuracy of the description was associated with the educational level of the observers. In a recent human study there was excellent agreement between neurologists and caregivers for seizure type when using a questionnaire based description of video-taped seizures (Benbir et al., 2013). Description of seizure events is certainly a function of memory and time. However, individuals remember these highly emotional events better than non-

emotional ones. Neuroimaging studies demonstrated that the amygdala plays a fundamental role during the encoding of emotional information (Kensinger et al., 2008). Individuals who show the greatest amygdala activity during the viewing of emotional items are those with the strongest emotional memory enhancement (Cahill, 2000; Kensinger et al., 2008). In the present study in cats with EUC, most owners (92%) were able to recall seizure semiology even after many years. Because seizures in animals are emotional events for owners, we propose that reliability of pet owner-derived descriptions of seizures are similarly valid as in humans.

This survey was retrospective and relied heavily on owner recollection. Another limitation, also noted in prior studies, was the lack of brain MRI of many cats in this study as structural epilepsy could not be completely excluded. Indeed, lesions in the olfactory bulb or frontal lobe may not cause interictal neurological deficits.

In conclusion, seizure semiology utilizing a structured questionnaire provides additional clinical information. Surprisingly, early onset of seizures in cats with EUC is associated with prolonged survival, and cats with EUC may become seizure free even in absence of AED. Semiology and seizure type, however, do not predict survival. Further prospective investigations are needed to confirm these findings.

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